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VOL. IX FALL ISSUE 1979 No. 3

The Siren Song of Sewage

A student finds glamour in wastewater treatment

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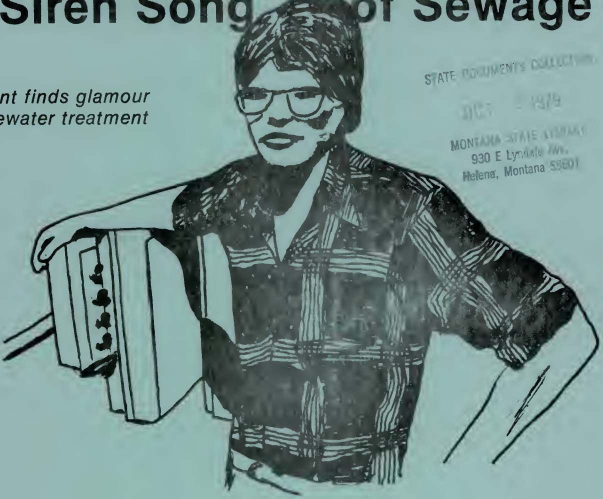

Annual School Issue

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Annual school set for Nov. 5-9

THE FORTY-SIXTH Annual School for Water and Wastewater Operators and Managers will be held Nov. 5 through Nov. 9 at the MSU Student Union Building in Bozeman. Most of you will notice that's smack in the middle of hunting season this year. Alas, we tried to avoid it, but we have to reserve rooms a year in advance -- and though we moved our dates up last year in order to miss hunting season, this year's season couldn't be avoided.

The school's format will be the same as before. There will be some joint water and wastewater sessions and some separate sessions. It'll cost the same as last year -- $45 per person -- and we will provide the participants with a free luncheon during the awards presentation on Friday. This must be the only fee in the whole country that has stayed within President Carter's wage-price guidelines in the past year!

The speakers featured at this year's school will be Dr. Robert Baumann and Dr. Edward Schroeder. Dr. Baumann is head of the Sanitary Engineering Division at Iowa State University. He is known internationally as an expert on water filtration and will be speaking about turbidity removal.

Dr. Schroeder is well-known as an authority on biological wastewater treatment. His topic will be "new ideas for small community wastewater systems."

Most of the sessions at this year's school will be held in the Madison and Jefferson Rooms at the Student Union. A tentative schedule follows.

This year's school promises to be a good one. We hope to see you in Bozeman.

PRELIMINARY SCHEDULE

Monday, November 5

Morning

8:00-1:15	REGISTRATION, Madison Room
9:00	Pre-school Workshop: Basic Math and Hydraulics, Jefferson Room
10:00	Break
10:30	Pre-school Workshop: Basic Chemistry, Jefferson Room
11:45	Lunch

Afternoon -- Joint Session -- Madison-Jefferson Rooms

1:15	Welcome (MSU Official) Response (MSDHES) Official
1:45	Water and Wastewater Operator Certification: Why, Who, How
2:15	Maintenance of Mechanical Equipment
3:15	Break
3:30	Chlorination Equipment Maintenance
4:00	Certification Test Preparation Workshop

Tuesday, November 6

Morning - Water Operators, Jefferson Room

8:00	Changes in Drinking Water Standards
9:00	Wells -- Construction, Operation and Maintenance
10:00	Break
10:30	Water Conservation
11:30	Lunch

Morning - Wastewater Operators, Madison Room

8:00	Innovative Alternative Technology
9:00	Aerosol Control
10:00	Break
10:30	Chemical Control of Weeds at Lagoons
11:30	Lunch

Afternoon - Water Operators, Jefferson Room

1:00	Fluoridation
2:00	Water Rights
3:00	Break
3:30	Record Keeping
4:00	Certification Workshop

Afternoon - Wastewater Operators, Madison Room

1:00	Activated Sludge Systems
1:30	Control Activated Sludge Systems, The Great Falls Experience
2:00	Control of Activated Sludge Systems, The Colstrip Experience
2:30	Control Activated Sludge Systems, The Butte Experience
3:00	Break
3:30	Round Table on Activated Sludge
4:00	Certification Workshop

Wednesday, November 7

Morning -- Joint Sessions -- Madison-Jefferson Rooms

8:00	Trenching Safety
9:00	Chlorination Safety
10:00	Break
10:30	Electrical Safety
11:30	Lunch

Afternoon -- Joint Sessions -- Madison-Jefferson Rooms

1:00	Turbidity Removal - Dr. Baumann
2:30	Break
3:00	Turbidity Removal - Dr. Baumann
4:00	Certification Test Preparation Workshop

Thursday, November 8

Morning -- Joint Sessions -- Madison-Jefferson Rooms

8:00	Secondary Treatment by Fixed Film Systems - Dr. Schroeder
10:00	Break
10:30	Secondary Treatment (continued) - Dr. Schroeder
11:30	Lunch

Afternoon - Water Operators, Jefferson Room

1:00	Preventive Maintenance - Water Distribution Systems
2:00	Freeze-Thaw Problem
3:00	Break
3:30	Certification Workshop - Chlorination Equipment Repair and Maintenance

Afternoon - Wastewater Operators, Madison Room

1:00	Sludge Disposal (Film)
1:30	Sludge Disposal - The Helena Experience
2:00	Sludge Disposal - The Havre Experience
2:30	Sludge Disposal - The Bozeman Experience

3:00	Break
3:30	Certification Workshop - Chlorination Equipment Repair and Maintenance

Friday, November 9

Morning -- Joint Sessions -- Madison-Jefferson Rooms

8:00	Cross Connections
9:00	Pumps
10:00	Break
10:30	Pumps (Bighorn-Yellowstone Rooms)
11:30	Lunch - Awards Banquet - Madison-Jefferson Rooms (Free Lunch)
1:00	School Dismissed!

Let's simplify operators' lives. . .please!

By George W. Strain
Operator, Great Falls Treatment Plant

I WATCHED the young mechanical engineer gazing at the maze of tubes and wires that were the controls for the discharge valve on my No. 5 high-service pump. His perplexed look amused me. It pointed eloquently to Strain's Law: "No machine should be too complicated for the simple task it must perform."

I prefer an efficient control on the discharge valve of any large, centrifugal pump. I'd take, any day, a ball valve with an electric/hydraulic (water) control that's manufactured by Willamette Iron and Steel in Portland, Ore. This control can be manually operated by pressing two simple levers. If there's an emergency, the operator can move quickly and avert extensive damage to the distribution system.

In our operation, the finished water is drawn from clearwells located under the treatment facility. If there were a power loss -- and the discharge valve remained open -- all the water from the distribution system would flow back into the clearwell, causing flooding and extensive damage. Quick action by the operator can keep this from happening -- but only if he doesn't have to pore over a complicated set of instruction before operating the valve.

I think it would be nice if pumps, valves and controls were all the same. In an older facility like ours, there are several different makes, models and ages of different designs. This creates an inventory and logistics problem that would send a seasoned Army supply sergeant to church.

I would suggest we stick with the most efficient models and phase out the older, obsolete ones. Especially in this era of energy conservation.

Chemical feeders could also benefit from standardization. I prefer the auger or worm drive varieties with an electric timer placed close to, but not actually on, the machine. This would help prevent damage from vibration that would throw off your feed rate. And as long as I'm making my Christmas list, I'd ask for a loading hopper -- whether manual or automatic -- that had a screen large enough to allow free flow while preventing chunks or debris from gumming up the feeder.

Water treatment is a fascinating career field that provides an important community service. The less time we spend being mechanics, the more time we can devote to our profession.

College student finds glamour in wastewater-treatment field

From the Billings Gazette

WAYNE SOLUM is part of the wave of the future in wastewater treatment. Solum, 20, is a Northern Montana College student who's in Billings as a summer intern at the city sewage treatment plant.

He's there partially because of the Environmental Protection Agency (EPA) and partially because he can't resist a good microbe.

In high school, Solum loved biology, and when a teacher took him on a tour of the Havre sewage plant, he got to look through the microscope there.

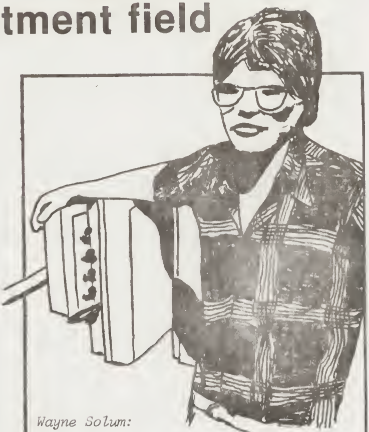
"I loved it," he said, sitting next to the powerful microscope in the Billings plant's lab. Hooked on the siren dance of the microbes, he decided to go to NMC and study biology.

He's spent the last two summers learning how to manage microbes and machines at sewage treatment plants. The plants are going through a good many changes both semantic and practical.

Semantically, they're conforming to the language of bureaucracy. For grant purposes, sewage plants are now wastewater or sanitation district treatment plants. The associate degree that Solum will earn this August will be in "Water and Wastewater Technology," a degree offered in Montana only at NMC.

Practically, plants are being required to operate with increasingly sophisticated equipment. On his days in the lab, Solum tests filters, checks water alkalinity and acidity with a pH monitor and looks through the microscope to make sure the right microbes are on the job.

During the summer, keeping the microbe work force balanced is a problem. Little stalked ciliates are the wastewater treatment technician's friends. When they glom onto a particle of sludge, the pudgy microbes drag it to the bottom of the settling tanks, from which the sludge is eventually removed and taken to the city landfill. Light filamentous microbes are another story. In hot weather they tend to take over the tanks, attach themselves to sludge and keep it floating. It's up to technicians to zap them when they get out of control.



Wayne Solum:

"I wouldn't have entered this field if I wanted the money."

SOME DAYS Solum forsakes the lab to learn how to operate the machinery and control the series of treatment tanks in the plant.

"I'm here to learn about the operations, to see how things work," he said. There's some maintenance, too. On Mondays I mow the lawns. That's part of the reason they could hire me. They needed somebody to help with the maintenance." The lawns are kept green with water from the plant, he added. For sheer technical superiority, Billings is a good training ground, he said, explaining that this plant is far more sophisticated than Bozeman's, where he studied last summer.

"I guess I get teased a lot about working in this field," Solum mused. "But it doesn't bother me that much. It's interesting work to me. It isn't that unglamorous of a job. A lot of women are getting into it ... A lot of people think you just shovel manure, but it's becoming a more technical process, and it's a cleaner job than it used to be."

He'd like to work for a few years, then get the bachelor's degree he'll need to qualify as a plant superintendent. But it's interest, not profit, that's prompting him.

"I wouldn't have entered this field if I wanted the money," Solum said. "I would have gone with the railroad and made twice as much. But I don't think I could work at a job that wasn't interesting.

Regular use of chemicals can help well yield

From the Johnson
Drillers Journal

A REDUCTION IN WELL YIELD may be ascribed to several causes: interference from additional local wells, especially if located in the same aquifer; decreasing watertable level caused by droughts or over-pumping, plus a decrease in capacity/efficiency of pump equipment due to wear; or, most commonly, the presence of incrustation. The latter results from deposits or accumulation of extraneous materials in the openings or pores of the formation particles and in the well screen which result in plugging.

Water quality has much to do with the occurence of incrustation. The kinds and amounts of dissolved minerals and gases in natural waters determine their tendency either to corrode metals or to deposit some of the mineral matter as incrustation. The dissolved substances in ground water are present in a rather delicately balanced condition. When something happens that upsets the balance, some of the minerals come out of solution and are deposited as solid substance. The scale that forms in the teakettle in which hard water is boiled is an example.

Modern research has made it possible to forestall corrosion through the development of well screens that can be made of any of several metals specifically resistant to the corrosive effect of a given type of water. Research findings in metals do not apply in the same way, however, to the prevention of incrustation. Thus, we address ourselves to the problem of clogging due to an incrustation buildup.

The more common form of incrustation, as noted above, is the hard, brittle, cement-like deposit, similar to the scale that forms in water pipes. Under different conditions it may be a soft, paste-like sludge, or a gelatinous material.

The different forms of incrustation in order of frequency of occurrence are: incrustation from precipitation of carbonates of calcium and magnesium or their sulfates; incrustation from precipitation of iron and manganese compounds, primarily their hydroxides or hydroled oxides; plugging due to slime produced by iron bacteria or other slime-forming organisms; plugging resulting from deposition of soil materials, such as silt and clay, carried in suspension to the screen.

Ground water normally moves very slowly through soil, sand and gravel and is thus in contact with the minerals for a very long time. The time is extended enough so that the water, with its dissolved mineral salts, is in complete equilibrium. It is holding in solution exactly the quantity of one or more minerals that the conditions will permit. Any change in the conditons throws the solution system out of equilibrium, and results in precipitation of insoluble materials.

Just as a change in pressure can result in the precipitation of calcium carbonate, so a change of velocity could conceivably cause an upset and result in the formation of insoluble iron and manganese hydroxides.

Well operators must realize that certain things must be done from time to time to maintain the structure in good condition, even though it is buried from sight. Operators must also acknowledge the importance of keeping good records. Since he cannot see what is happening at the bottom of the well, the operator must depend on records of pumping rates, drawdown, total hours of operation, power used, water analysis and other pertinent data to ascertain what might be going on. Good records can provide the soundest basis for deciding what maintenance procedures would most likely give best results.

CHEMICAL ANALYSIS of the water, for example, would be much more useful if samples were taken at regular intervals. Certain general conclusions can be drawn from the results to indicate the type and rate of incrustation that might occur. Appropriate preventive action can thus be undertaken.

A drop in well specific capacity often indicates plugging of the formation pores and screen openings. One cannot really determine the severity of plugging because the area cannot physically be inspected. It must, therefore, be assumed that the extent of incrustation is severe.

Over the years, numerous devices and methods coupled with different chemical combinations have been used to rehabilitate wells both in sand and gravel aquifers and in rock-consolidated formations. Although successful in some instances, these have been mostly "hit-or-miss" procedures.

In recent years, field experience has shown that alternate treatments of chlorine and acid produce excellent results, in most cases obtaining specific capacities equal to those recorded when the well was originally drilled and tested. The chlorine attacks and helps to remove the slime deposited by iron bacteria, whereas the acid readily dissolves calcium and magnesium carbonates. It's suggested this combination treatment be repeated as many times as it produces beneficial results.

Enough chlorine should be used to create what is described as a shock treatment. Typically, a chlorine concentration of at least 500 ppm is used with a contact period of at least 1, preferably 24, hours. It requires approximately 6.4 lbs of granular chlorine having 65 percent available chlorine for each 100 gallons of water to obtain a 500 ppm chlorine solution. It is advisable to dissolve the granular chlorine in a mixing container of water at the surface rather than dump it into the well in its dry form. Otherwise, the full strength chlorine will come in direct contact with pump parts, well casing and the screen. After introducing the chlorine solution, a quantity of water 50 to 100 times the volume of water standing in the well should be added, thus forcing the chlorine solution out into the surrounding formation. For best results, some form of agitation should be periodically conducted during this time, especially during the first few hours while the solution produces its strongest effect. All traces of the chlorine should be purged from the well before introduction of the acid.

Many forms of acid have been and are still being used to treat plugged wells. Two widely used acids are hydrochloric (muriatic), and sulfamic. Sulfamic acid attacks metals more slowly than does HCl. The corrosive effect on well casings, pumping equipment and screens is considerably less. It will have little or no effect on Type 304 stainless steel well screens. Recent years have seen great strides in the development of easy-to-handle, effective and reasonably inexpensive treatment agents like Johnson's pelletized Nu-Well that incorporates a special inhibitor, making it usable in both metallic and non-metallic materials.

The amount of these agents needed to

successfully treat a screen and plugged aquifer depends upon the type of incrustant, the degree of plugging and the size of the screen. Follow instructions, of course.

THE PUMP may remain in the well to provide agitation if desired and if sufficient clearance is available between the pump O.D. and the I.D. of the casing. It should be remembered that some pelletized agents are approximately 11/16 inch by 5/8 inch. (If this method is used, the pump manufacturer should be contacted to ascertain the sensitivity to a low pH environment of the impellers and other parts.) Thus, the pump may be placed on a start-stop operation to spread coverage and speed breakup of the incrustant. Even if the pump is to be used in the treatment process, it should be removed for inspection and possible cleaning and repairs after the well rehabilitation.

One method of agitation is to seal the top of the well, and alternately introduce and release compressed air in order that the water level in the well is moved up and down. By placing a drilling rig over the well, a conventional surge block method may also be used.

Compressed air may also be used with the well head open, but the work must be handled in such a way that the solution is not blown out of the well before the expiration of the necessary contact time. If too much solution is removed each time the water is lifted by the air, then the acid solution is wasted.

In some instances, agitation with a high velocity water jet has been helpful. However, one should be cautioned that this scheme can be hazardous to personnel. If this method is to be used, then it's important that the acid solution be fully spent before starting to jet, at which time the formation may be developed removing all incrustant particles as well as any formation fines that may have collected and contributed to the plugging problem.

Wells completed with many feet of alternate screens and sections of blank pipe or slotted pipe or open hole in hard rock are more difficult to rehabilitate. Considerable success has been obtained, however, by acid treating.

Once again, it is vital that some form of agitation be employed in order that the solution can penetrate the various openings.

One other point should be made. In many instances screens - and especially drive points - have been removed because of plugging. New units have been installed only to plug again in a few months. The problem here is that while replacing the screen solved the problem of a plugged screen face, the formation surrounding the screen remained plugged. It is thus vital that chemical treatment be performed on each well when the screen or point is replaced.

Chemical treatment used on a regular basis can help wells maintain their yield and efficiency. In rehabilitation, it can restore wells to useful production where they might once have been abandoned. In either case, complete record keeping and careful application and handling of the chemicals are essential.

Some training on legalities

The University of Wisconsin will hold a training seminar on the legal aspects of public water utility operations Nov. 7-8 in Madison, Wis.

The seminar will cover topics including the Safe Drinking Water Act, tort liability, contracts, water rights and disconnecting service. Guest speakers include law professors, attorneys and government officials.

The program, sponsored by the UW Engineering Department's extension service, will be held in Madison's Wisconsin Center. You must register in advance and can do it by calling (608) 262-1299. The fee for the seminar is $150 per person.

The Ammeter:

amp-le way to find your pump problems

From the Water & Sewage Works
Reference Number 1979

Figure 1.

Hand-held ammeter.

AN AMMETER can be a very useful tool in narrowing in on specific causes of pump problems -- helping the operator avoid pump disassembly and a lot of hard work. Ammeters often are overlooked for pump maintenance because few operators understand the relationship between pump performance and the amount of electrical current drawn by the pump.

Figure 2 on this page is typical of the relationship between a pump's horsepower demand and the amperage that would be measured on the lead wire from the pump motor. There is a nearly direct proportionality between current required, horsepower used, and watts of power consumed.

Manufacturers of sewage and water pumps will provide the expected maximum running amps and locked-rotor amps for a particular pump-and-motor combination -- for example, "This model will draw 23.5 amps when running and 65 amps when locked."

The running amperage is the normal amp draw under normal load. The locked-rotor amperage is that recorded when the pump impeller is frozen or wedged tight. Control-panel circuit breakers are designed to trip somewhere between the maximum running and locked-rotor amps to protect the motor from overheating and burnout.

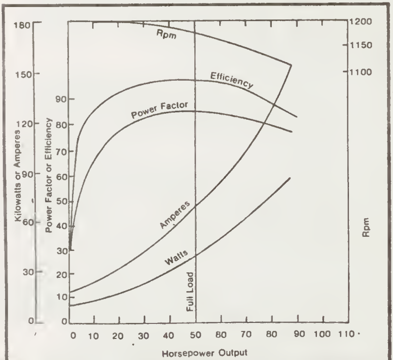


Figure 2. Typical performance of a 50 hp six-pole, three-phase motor tested at 440v.

Constant-speed pump-and-motor combinations at rest have a much higher torque demand at first in order to bring the pump up to synchronous motor speed. Figure 4 shows typical initial torque and amperage curves for a constant-speed motor during which time the pump is brought up to full speed. This initial amperage can be a reasonable approximation of locked-rotor amperage.

The initial current demand typically can be five to seven times that of normal running. This is why lights dim in a building when you turn on a pump -- especially in buildings with insufficient wiring sizes to handle the large current in-rush.

EXPERIENCED pump-service personnel who troubleshoot pumps full-time frequently use ammeters. It would be even better if they used an ammeter regularly to record a pump's current draw, noting any variation from the norm.

Figure 5 is a typical centrifugal pump curve which can be used to illustrate the application of ammeters to pump troubleshooting.

Here's a sample problem:

A centrifugal pump -- satisfying Figure 5 -- is designed to handle 5400 Gpm at 70 feet of head and is furnished with a 9-inch diameter impeller. The impeller will always operate along the impeller curve line no matter what occurs. If there were a plug or a frozen force main at the discharge of the pump, it would operate at 0 Gpm or "shutoff," and the head shown on the head gauge located at the pump's discharge would read 90 feet. If there were a broken force main just outside the station, the pump would try to pump in excess of 1,200 Gpm.

According to Figure 2, the current measured in the lead wires of a pump motor will increase or decrease directly with the horsepower demands for the motor. In Figure 5, the horsepower demand diminishes as the capacity of the pump decreases. Similarly, the horsepower demand grows as the pump capacity increases.

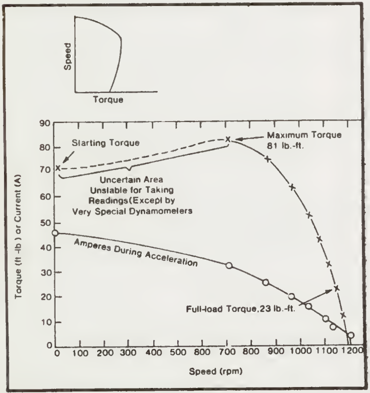


Figure 4. Constant-speed motor torque-amperage performance.

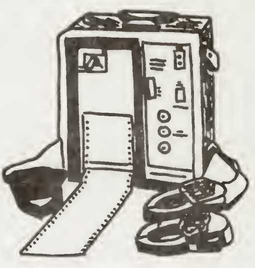


Figure 3. Portable three-wire recording ammeter.

Once the operator has recorded the normal running amperage for the pump under operating conditions, it is possible to deduce the following:

1. If the pump current is measured and found less than normal, there is the probability of a plugged force main or a closed valve on the discharge side of the pump.

2. If the pump amperage is greater than normal and there's no broken force main, there's possibly

   - -- a badly plugged pump, or
   - -- a pump with drag on the impeller (such as caused by a stringy material wrapped around the shaft on top of the impeller).

3. If the pump amperage is greater than normal and the pump is vibrating or cavitating, the pump may be rotating in the wrong direction. There have been cases in which electricians or electric utilities

have reversed the phases on a three-phase-motor feeder line.

4. If the pump amperage is less than normal and the pump is cavitating or vibrating excessively, a restricted suction (such as a plugged pump suction line) may be the culprit.

THE FOLLOWING are some recommendations for operators:

1. Acquire a good ammeter and use it for pump service and maintenance inspections.
2. Make periodic checks and record the running amps of each pump.
3. Ask the pump manufacturer for a current-vs.-capacity curve along with the customary certified pump test data for new pumps.
4. Consider the possibility of installing ammeters as a ready check for normal operation in more sophisticated pumping stations where flow meters are not available or haven't been installed.

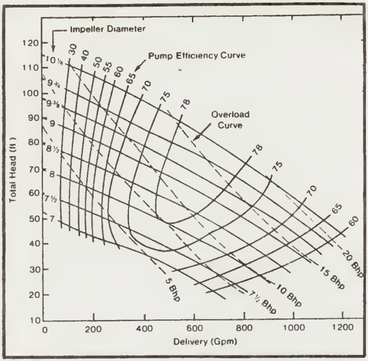


Figure 5. Typical centrifugal pump curve.

There are other ways to measure the operation of centrifugal pumps, including pump-efficiency checks and flow monitoring. These measures, however, involve more sophisticated techniques and require additional measuring equipment.

Training jobs open at Water Quality Bureau

The Water Quality Bureau is looking for two new training officers.

Chuck Harper, who has been a training officer with the bureau since November 1977, resigned in September to accept a job elsewhere. Tim Hunter, who has been a training officer for about a year, has been promoted, leaving his position open also.

Applicants for these positions should have at least two years experience in the operation of water and/or wastewater treatment facilities and a bachelor's degree in chemistry, biology, mathematics, microbiology or engineering; or any equivalent combination of education and experience.

The annual salary range is $14,098 to $18,591.

We would like to fill one of these positions with someone experienced in water treatment and the other position with a person experienced in wastewater treatment.

If you are interested, please contact Melva Rude, personnel officer, Montana Department of Health and Environmental Sciences, Capitol Station, Helena, MT 59601. Her phone number is 449-2442.

Manhole leads to a tragedy

TWO MEN DIED and two others were placed in intensive care as a result of a recent sewer collection system accident. (Place and time withheld by request -- it was not in Montana).

Five employees of a small municipality were engaged in the replacement of a submersible pump in a wet pit.

- Man #1 descended into the manhole to disconnect the pump. On the way up the ladder, he fell to the bottom - where he died.

- Man #2, who descended into the manhole in a rescue attempt, was overcome with chemical fumes, and died.

- Men #3 and #4, who also descended into the manhole in a resuce attempt, were overcome with the fumes, but survived.

- Man #5 radioed for help, got it, and was uninjured.

The cause of death for Men #1 and #2 was reported to be drowning, although they showed traces of H_2S. The cause of the accident was probably a combination of H_2S and oxygen deficiency.

The crew did not have a blower on the truck because it was in the shop for repairs. The municipality was reported to own a gas detector, but it was inoperable. None of the men wore a safety harness.

The accident would not have happened if the manhole had been ventilated. H_2S is heavier than air and concentrates at the bottom.

What should you do when you see your buddy pass out in a manhole?

- Decide in advance not to be a dead hero *and* an ineffective rescuer.

- Send for help. The fire department is best.

- Get a blower going.

- Descend only in a harness. Have enough people on the rope to pull *you* out.

Fluoridation grants available

APPROXIMATELY 40 Montana communities are eligible to apply for Department of Health, Education and Welfare grants for fluoridation of local water systems, according to Dr. A.J. Terrill, Chief of the Dental Bureau, State Department of Health and Environmental Sciences.

The nationwide fluoridation grants will be available Oct. 1 and communities may now apply for funds.

Dr. Terrill said that any community having a population of 1,000 or more persons and a fluoride level which does not exceed 0.7 parts per million is eligible to apply.

Communities applying for the funds will be expected to supply such information as:

-- the unadjusted fluoride level of the current water supply;

-- size of the population served by the water system;

-- statement of approval for fluoridations by local governing body; and

-- the installation plans for the proposed fluoridation system.

Local communities interested in obtaining federal funding for fluoridation projects should contact Dr. A.J. Terrill, Chief of the Dental Bureau, Montana Department of Health and Environmental Sciences, Cogswell Building, Helena, Montana, 59601, phone (406) 449-3429.

Available chlorine content cut to 65%

AN INDUSTRY-WIDE CHANGE has reduced the available chlorine in commercial calcium hypochlorite to 65 percent. Until recently, the amount had been 70 percent.

The change means you'll have to increase the feed rate on your hypochlorinator or increase the amount of chemical placed into solution as your feed stock. You will need about 108 percent of the amount of chemical you were using with the 70-percent available chlorine.

The industry reduced the available chlorine content in calcium hypochlorite to minimize the fire hazard associated with the storage and use of the chemical. But to be even safer, be sure to read the label on the container.

Operator Certification Corner

SAMPLE CERTIFICATION TEST QUESTIONS:

1. The effluent discharge from a wastewater treatment plant is flowing at 3 MGD and has a BOD_5 of 25 mg/l. The receiving stream is flowing at 1000 CFS. The BOD_5 in the stream above the treatment plant discharge is 4 ppm. What is the BOD_5 of the stream below the point of discharge after mixing has taken place?

2. A lagoon measures 500 feet x 1000 feet and averages 4½ feet deep.

   a. What is its surface area?
   b. What is its volume in cubic feet?
   c. How many gallons does it contain?

3. What is the pressure in PSI at the bottom of a cylindrical tank with a radius of 25 feet and a depth of 15 feet?

4. What horsepower is required to pump 300 GPM against 150 feet head when the overall efficiency of pump and motor is 70 percent?

5. A chlorine cylinder weighs 250 pounds when full. When empty, the same cylinder weighs 125 pounds. If the chlorinator is set to use 5 pounds of chlorine in 24 hours, how many days can the cylinder be expected to last before replacing it with a full one?

ANSWERS:

1. Use the formula:

$$C_3 = \frac{(C_1 \times V_1) + (C_2 \times V_2)}{V_1 + V_2}$$

Where: C_3 = concentration of mixture
C_1 = concentration of #1 solution
C_2 = concentration of #2 solution

V_1 = volume of #1 solution
V_2 = volume of #2 solution

- -- The volume is the volume of flow.
- -- The concentrations are the BOD_5 values.
- -- Solution #1 is the plant effluent discharge.
- -- Solution #2 is the receiving stream.

Now convert so that all units for volume and concentration are the same. The labels mg/l and ppm represent the same value. Therefore, 4 ppm is the same as 4 mg/l.

Now change 1000 CFS to MGD:

$$1000 \frac{\cancel{ft^3}}{\cancel{sec}} \times 7.5 \frac{gal}{\cancel{ft^3}} \times 60 \frac{\cancel{sec}}{\cancel{min}} \times 60 \frac{\cancel{min}}{\cancel{hr}} \times 24 \frac{\cancel{hr}}{day} = 648{,}000{,}000 \text{ gal/day} = 648 \text{ MGD}$$

So:
C_1 = 25 mg/l
V_1 = 3 MGD
C_2 = 4 mg/l
V_2 = 648 MGD

Now substitute into the formula:

$$C_3 = \frac{(25 \text{ mg/l} \times 3 \text{ MGD}) + (4 \text{ mg/l} \times 648 \text{ MGD})}{3 \text{ MGD} + 648 \text{ MGD}} = 4.1$$

Answer: 4 mg/l BOD_5 in the stream below the discharge.

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2. a. Area = length x width
A = 500 ft. x 1000 ft.
A = 500,000 ft.

b. Volume = length x width x depth
V = 500 ft. x 1000 ft. x 4.5 ft.
V = 2,250,000 ft^3

c. To change to gallons, divide by 7.5 gal/ft^3

$$2{,}250{,}000 \text{ ft}^3 \times 7.5 \frac{\text{gal}}{\text{ft}^3} = 16{,}875{,}000 \text{ gal.}$$

3. Use the formula: PSI = .43 x depth

PSI = .43 x 15 ft.

Answer: 6.45 PSI

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4. Use the formula:

$$\text{Horsepower} = \frac{\text{GPM} \times \text{Head (ft)}}{3690 \times \%\text{efficiency}}$$

$$\text{Horsepower} = \frac{300 \times 150}{3690 \times .70} = \frac{45{,}000}{2{,}583} = 17.42$$

Answer: 17.42 Horsepower

5. 250 lbs. full weight of cylinder
-125 lbs. empty weight of cylinder
125 lbs. chlorine in cylinder

125 lbs. ÷ 5 lbs/day = 25 days

Answer: 25 days

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